

ELM-Free, Sawtooth-Free H-Mode Discharges on DIII-D with Density and Impurity Control

by

K.H. Burrell, C.M. Greenfield,
M.A. Makowski,^{*} M.R. Wade,[†] T.H. Osborne,
J.C. Rost,[‡] B.W. Stallard,^{*} and W.P. West

^{*}Lawrence Livermore National Laboratory

[†]Oak Ridge National Laboratory

[‡]Massachusetts Institute of Technology

Presented at
the American Physical Society
Division of Plasma Physics Meeting
Seattle, Washington

November 15–19, 1999



Abstract Submitted
for the DPP99 Meeting of
The American Physical Society

Sorting Category: 5.1.1.2 (Experimental)

Sawtooth-free H-mode Discharges on DIII-D with Density and Impurity Control¹ K.H. BURRELL, C.M. GREENFIELD, C. ROST, M.R. WADE, W.P. WEST, DIII-D National Tokamak Program — By utilizing cryopumping to control the edge plasma density, ELM-free and sawtooth-free H-mode plasmas have been produced using neutral beam counter-injection in single-null divertor plasmas in DIII-D. Unlike most ELM-free discharges, these shots exhibit density, impurity, and radiated power levels which are constant in time throughout the ELM-free phase. This ELM-free and sawtooth-free state has lasted for up to 2500 ms, limited only by the neutral beam durations chosen. A critical input power above about 7.5 MW and critical line averaged density below about $3 \times 10^{19} \text{ m}^{-3}$ are required to reach this state. The presence of substantial edge pedestals in electron density and temperature and in ion temperature and rotation clearly indicates that these discharges are in H-mode. The confinement in these shots is at the standard H-mode level; relative to the ITER89P scaling, normalized confinement (H-factor) values are 1.8 to 2.4 depending on the neutral beam power used. The H-factor increases with increasing neutral beam power. At the highest power attempted, 12 MW, the normalized beta was 2.4.

¹Supported by U.S. DOE Contracts DE-AC03-99ER54463 and DE-AC05-96OR22464, and Grant DE-FG02-91ER54109.

Prefer Oral Session
 Prefer Poster Session

K.H. Burrell
burrell@gav.gat.com
General Atomics

Special instructions: DIII-D Contributed Oral Session, immediately following M Murakami

Date printed: July 15, 1999

Electronic form version 1.4

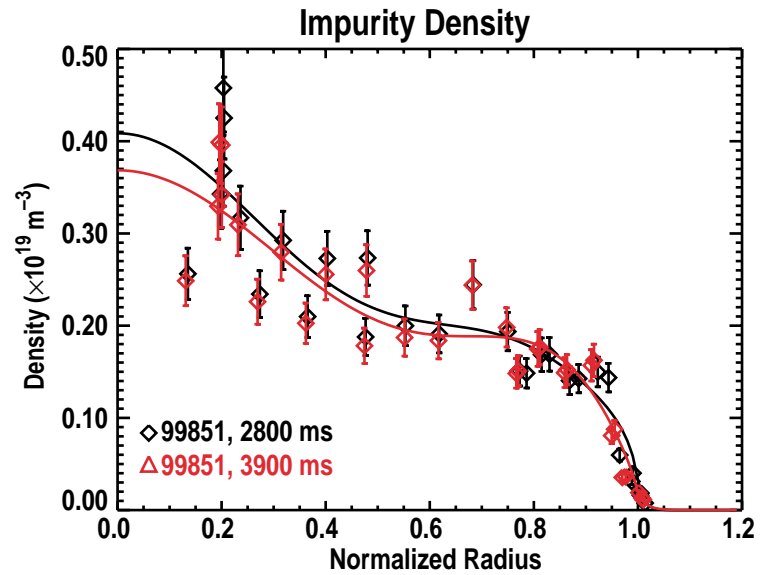
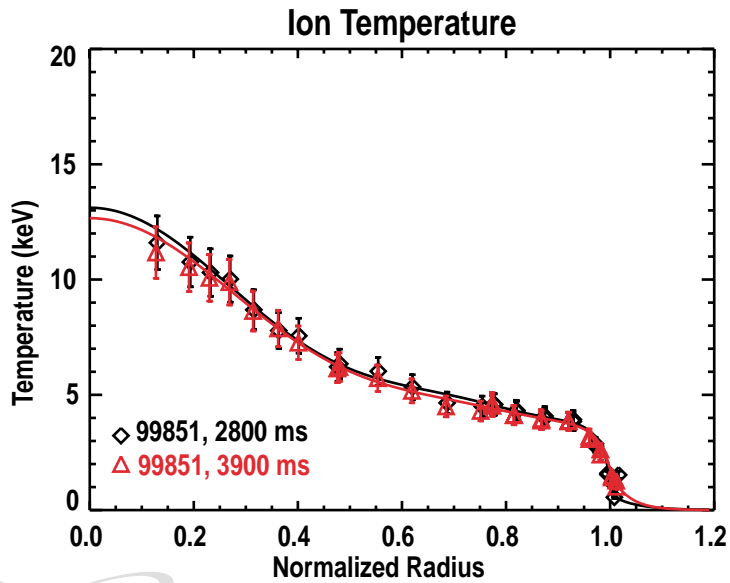
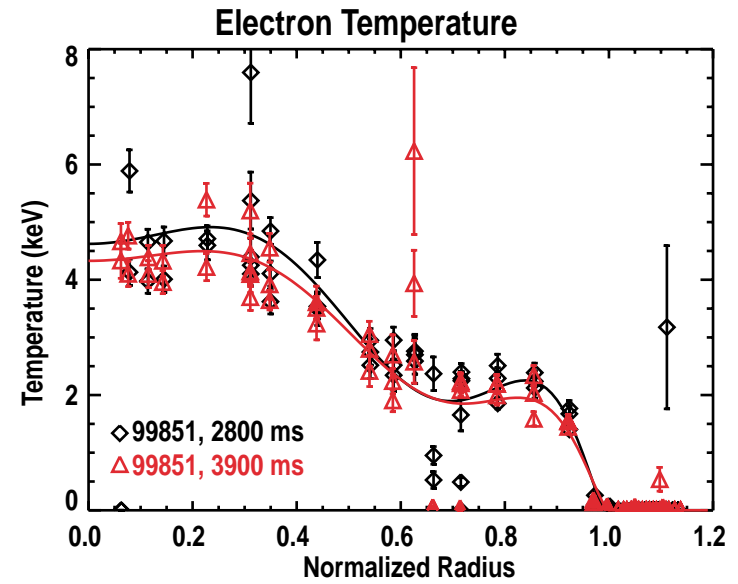
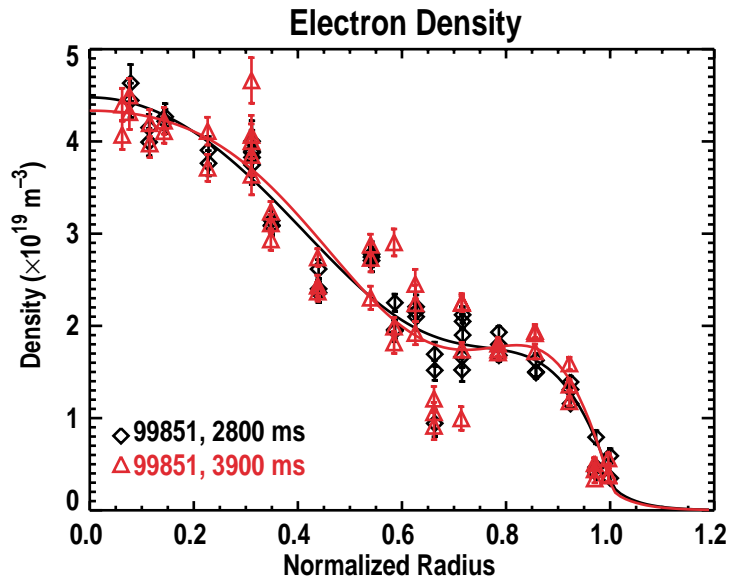
ELM-FREE, SAWTOOTH-FREE, STEADY-STATE H-MODE

- Steady-state H-mode plasmas without sawteeth or ELMs have been produced in single-null divertor discharges in DIII-D
- Key conditions were: (1) counter-injection, (2) cryopumping to lower the density ($\lesssim 3 \times 10^{19} \text{ m}^{-3}$), (3) beam power $\geq 7.5 \text{ MW}$ at 2.0 T
- Even without ELMs, these shots had constant density, constant impurity levels and constant radiated power fraction ($\lesssim 35\%$) for up to 2.5 seconds, limited only by the beam duration chosen
- Shots are H-mode as shown by the edge pedestals and confinement quality
 - H_{99p} from 1.8 to 2.4, increasing with P_{beam} from 7.5 to 12 MW
 - β_N values up to 2.4
 - Highest power shots run into beta limit and disrupt

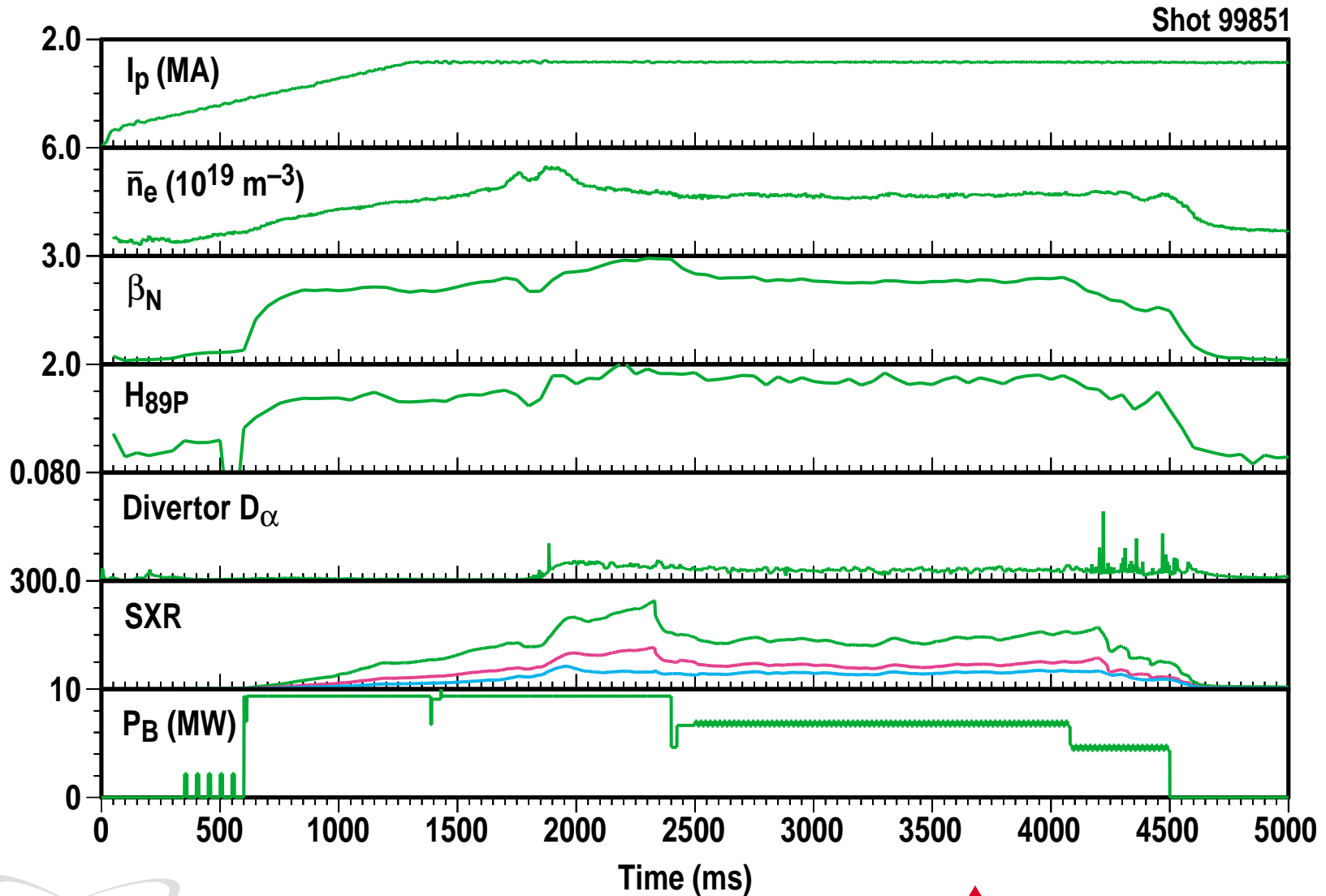
ELM-FREE, SAWTOOTH-FREE, STEADY-STATE H-MODE (Continued)

- Significant coherent edge MHD activity may provide the particle transport needed for steady-state operation
 - This MHD has multiple, coherently coupled toroidal modes ($1 \leq n \lesssim 9$)
 - Divertor D_α level increases when this suite of modes starts
 - May be saturated ELM precursors
- If we can find out how to produce these shots under reactor-relevant conditions, they would be a reactor designer's dream
 - H-mode confinement quality
 - No pulsed divertor heat load from giant ELMs

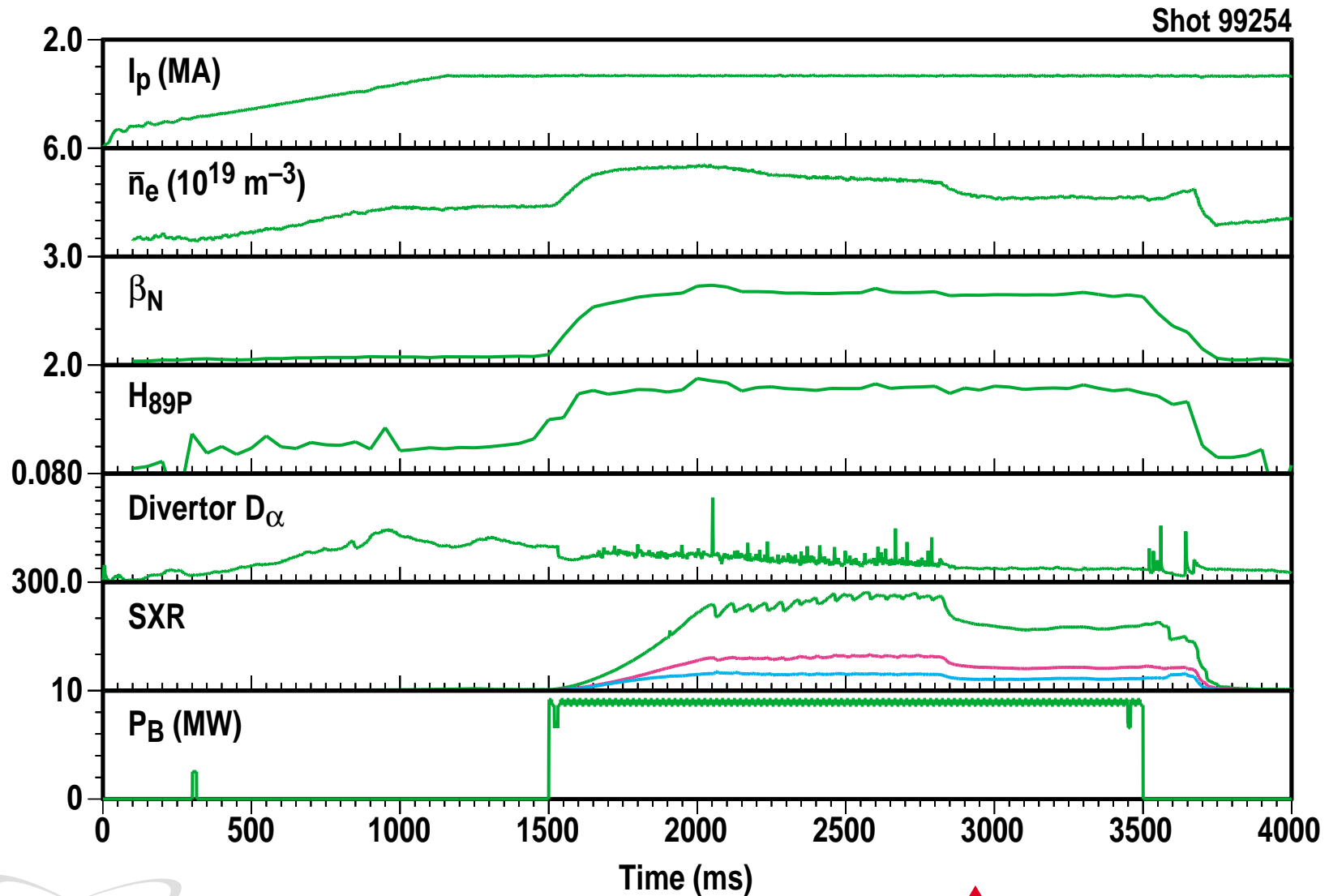
STEADY-STATE, ELM-FREE, SAWTOOTH-FREE H-MODE



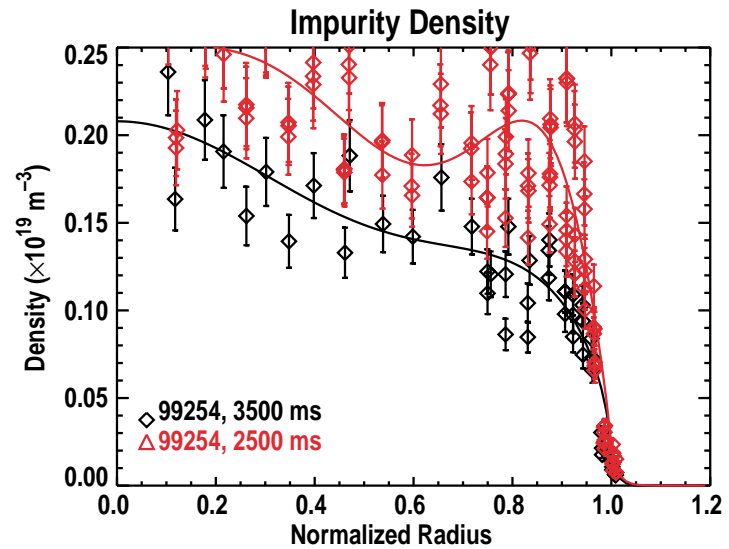
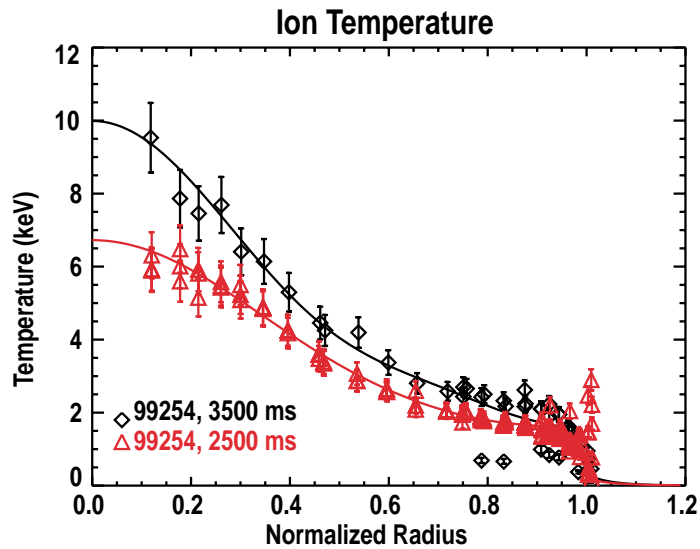
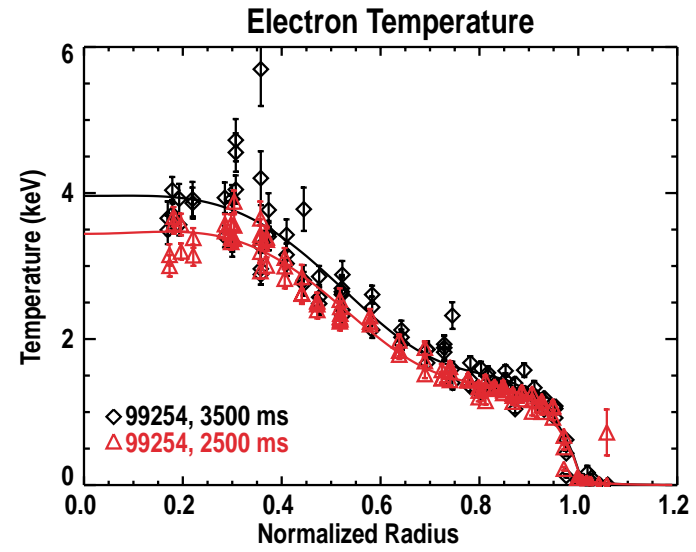
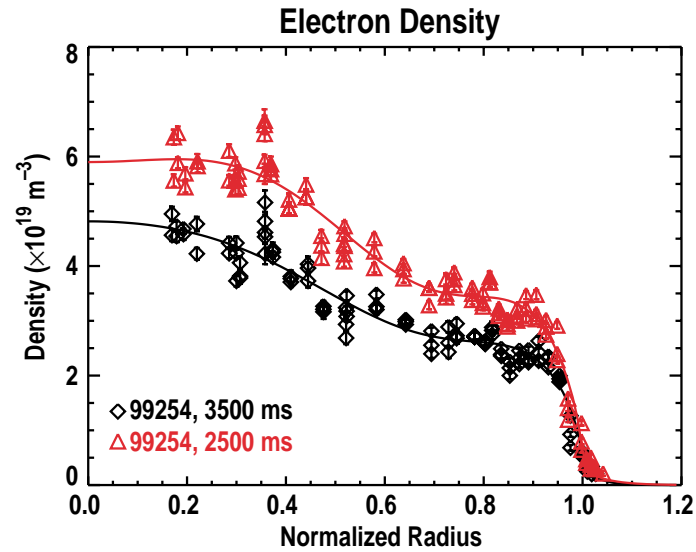
STEADY-STATE, ELM-FREE, SAWTOOTH-FREE SHOT WITH DENSITY CONTROL



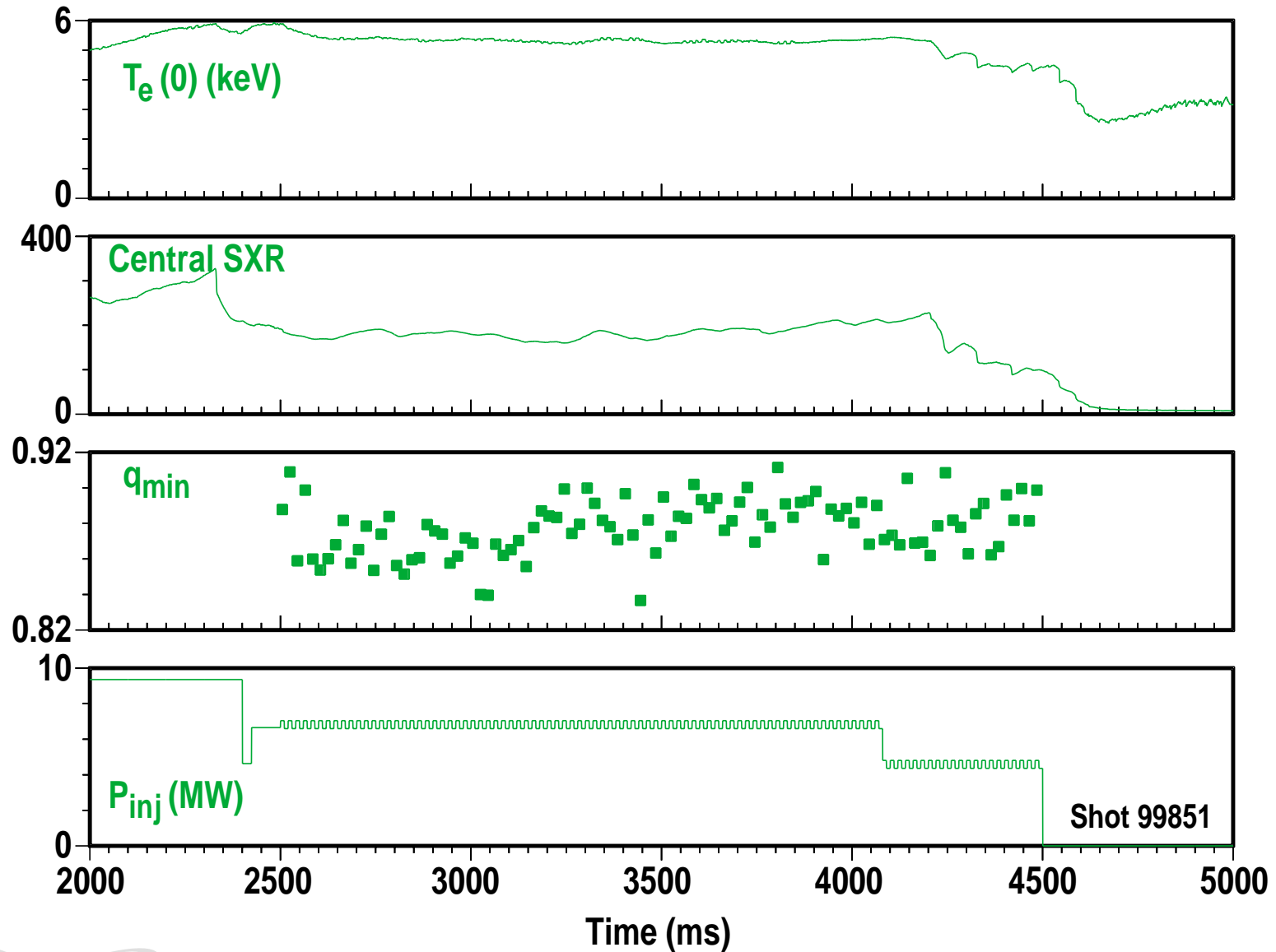
ELMs AND SAWTEETH SUPPRESSED AFTER CRYOPUMPING REDUCES DENSITY



EDGE PEDESTAL DEMONSTRATES ELM-FREE TIME IS H-MODE



STEADY-STATE, SAWTOOTH FREE SHOT WITH $q_{\min} < 1$



CARBON IMPURITY LEVEL AND RADIATED POWER DO NOT INCREASE IN ELM-FREE PHASE

